CLAIM + DETAILED DESCRIPTION

[Claim(s)]

[Claim 1]An amplitude limiting means which FM signal is inputted and holds down maximum voltage amplitude of said FM signal to a steady value, A phase shift means to which an output signal of said amplitude limiting means is inputted into, and only the specified quantity moves a phase of said FM signal, Have the 1st and 2nd input edges and an output signal of said amplitude limiting means is inputted into said 1st input edge, An output signal of said phase shift means is inputted into said 2nd input edge, provide a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between an outgoing end of said amplitude limiting means, and a power supply terminal, A voltage current conversion means by which an outgoing end is connected to a connecting point of said 1st and 2nd capacitors, FM recovery circuit, wherein it comprises a low pass filter means connected to an input edge of said voltage current conversion means and a connecting point of said 1st and 2nd capacitors is connected to the 2nd input edge of said multiplication means.

[Claim 2]An amplitude limiting means which FM signal is inputted and holds down maximum voltage amplitude of said FM signal to a steady value, A phase shift means to which an output signal of said amplitude limiting means is inputted into, and only the specified quantity moves a phase of said FM signal, Have the 1st and 2nd input edges and an output signal of said amplitude limiting means is inputted into said 1st input edge, An output signal of said phase shift means is inputted into said 2nd input edge, provide a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between an outgoing end of said amplitude limiting means, and a power supply terminal, A transistor by which a collector is connected to a connecting point of said 1st and 2nd capacitors, and an emitter is connected to said power supply terminal, Resistance connected between a base of said transistor, and a collector, and the 3rd capacitor connected with a base of said transistor between said power supply terminals, FM recovery circuit, wherein it comprises a source of current connected to a collector of said transistor and a connecting point of said 1st and 2nd capacitors is connected to the 2nd input edge of said multiplication means.

[Claim 3]An amplitude limiting means which FM signal is inputted and holds down maximum voltage amplitude of said FM signal to a steady value, A phase shift means to which an output signal of said

amplitude limiting means is inputted into, and only the specified quantity moves a phase of said FM signal, Have the 1st and 2nd input edges and an output signal of said amplitude limiting means is inputted into said 1st input edge, An output signal of said phase shift means is inputted into said 2nd input edge, provide a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between an outgoing end of said amplitude limiting means, and the 1st power supply terminal, The 1st transistor by which a collector is connected to a connecting point of said 1st and 2nd capacitors, and an emitter is connected to said 1st power supply terminal, The 2nd transistor by which a collector is connected to the 2nd power supply terminal, and an emitter is connected to a base of said 1st transistor, A differential means by which one input edge is connected to a connecting point of said 1st and 2nd capacitors, and an input edge of another side is connected to a base of said 2nd transistor, It comprises the 3rd capacitor connected with a source of the 1st current connected to a collector of said 1st transistor, a source of the 2nd current connected to an emitter of said 2nd transistor, and a base of said 2nd transistor between said 1st power supply terminals, FM recovery circuit, wherein an emitter of said 2nd transistor is connected to the 2nd input edge of said multiplication means.

[Claim 4]An amplitude limiting means which FM signal is inputted and holds down maximum voltage amplitude of said FM signal to a steady value, A phase shift means to which an output signal of said amplitude limiting means is inputted into, and only the specified quantity moves a phase of said FM signal, Have the 1st and 2nd input edges and an output signal of said amplitude limiting means is inputted into said 1st input edge, An output signal of said phase shift means is inputted into said 2nd input edge, provide a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between an outgoing end of said amplitude limiting means, and the 1st power supply terminal, A transistor by which a base is connected to a connecting point of said 1st and 2nd capacitors, a collector is connected to the 2nd power supply terminal, and an emitter is connected to said 1st power supply terminal via a source of the 1st current, A differential means by which one input edge is connected to a source of reference voltage, an input edge of another side is connected to an emitter of said transistor via resistance, and an outgoing end is connected to a base of said transistor, FM recovery circuit, wherein it comprises the 3rd capacitor connected with an input edge of another side of said differential means between said 1st power supply terminals and an emitter of said transistor is connected to the 2nd input edge of said multiplication means.

[Claim 5]FM recovery circuit given in any 1 paragraph of Claims 1-4, wherein said amplitude limiting means, said phase shift means, and said multiplication means are accumulated into 1 chip.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]In this invention, it is related with FM detection circuit.

Therefore, it is especially used for FM recovery circuit aiming at reduction of external parts.

[0002]

[Description of the Prior Art]Drawing 5 is a block diagram showing the conventional FM recovery circuit. This FM recovery circuit comprises three blocks, the amplitude limiting means 111, the phase shift means 112, and the multiplication means 113, and FM signal is inputted into the amplitude limiting means 111. The amplitude limiting means 111 is an automatic-gain-control (AGC) circuit, for example.

It plays the role which holds down the maximum voltage amplitude of FM signal to a steady value.

The phase shift means 112 moves the specified quantity, for example, 90 degrees, of the phase of FM signal. The multiplication means 113 carries out the multiplication of the output signal of the amplitude limiting means 111, and the output signal of the phase shift means 112, and outputs FM recovery signal.

[0003]Drawing 6 shows the composition of the phase shift means of drawing 5.

Drawing 7 extracts and shows only a phase shift means.

Drawing 8 is a phase characteristic figure of the phase shift means of drawing 7. The phase shift means comprises a parallel resonant circuit of the coil L, the resistance R, and the capacitor C. The relation between the input voltage VIN and the output voltage VOUT comes to be shown in (1) type.

[0004]

[Mathematical formula 1]

$$V_{OUT} = \frac{-\omega^2 C1LR}{R\{1-\omega^2 L(C+C1)\}+j\omega L} V_{IN} \quad \cdots (1)$$

Resonance frequency omega0 is shown in (2) types, and **** theta comes to be shown in (3) types.

[0005]

[Mathematical formula 2]

$$\omega_0 = \frac{1}{2\pi\sqrt{L(C+C1)}} \quad \cdots (2)$$

[0006]

[Mathematical formula 3]

$$\theta = \tan^{-1}\frac{0}{-\omega^2 LC1R} - \tan^{-1}\frac{\omega L}{R\{1-\omega^2 L(C+C1)\}}$$

$$= 180^\circ - \tan^{-1}\frac{\omega L}{R(1-\omega^2/\omega_0^2)} \quad \cdots (3)$$

[0007]

[Problem to be solved by the invention]When the parallel resonant circuit which becomes a phase shift means from the coil L, the capacitor C, and the resistance R as shown in drawing 6 in FM recovery circuit of drawing 5 is used, can accumulate an amplitude limiting means and a multiplication means into 1 chip, but. It cannot be accumulated into 1 chip but a phase shift means (parallel resonant circuit) serves as external. Therefore, there is a fault which causes increase of the number of pins of IC and the increase in external parts.

[0008]It was made that this invention should solve the above-mentioned fault, and the purpose is to provide

FM recovery circuit of new composition of that external parts can be reduced by accumulating a phase shift means into one chip (IC) with an amplitude limiting means and a multiplication means.

[0009]

[Means for solving problem]In order to attain the above-mentioned purpose, [FM recovery circuit of this invention] The amplitude limiting means which FM signal is inputted and holds down the maximum voltage amplitude of said FM signal to a steady value, The phase shift means to which the output signal of said amplitude limiting means is inputted into, and only the specified quantity moves the phase of said FM signal, Have the 1st and 2nd input edges and the output signal of said amplitude limiting means is inputted into said 1st input edge, The output signal of said phase shift means is inputted into said 2nd input edge, have a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between the outgoing end of said amplitude limiting means, and a power supply terminal, An outgoing end comprises a voltage current conversion means connected to the connecting point of said 1st and 2nd capacitors, and a low pass filter means connected to the input edge of said voltage current conversion means, and the connecting point of said 1st and 2nd capacitors is connected to the 2nd input edge of said multiplication means.

[0010]The amplitude limiting means to which FM signal is inputted and FM recovery circuit of this invention holds down the maximum voltage amplitude of said FM signal to a steady value, The phase shift means to which the output signal of said amplitude limiting means is inputted into, and only the specified quantity moves the phase of said FM signal, Have the 1st and 2nd input edges and the output signal of said amplitude limiting means is inputted into said 1st input edge, The output signal of said phase shift means is inputted into said 2nd input edge, have a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between the outgoing end of said amplitude limiting means, and a power supply terminal, The transistor by which a collector is connected to the connecting point of said 1st and 2nd capacitors, and an emitter is connected to said power supply terminal, The resistance connected between the base of said transistor, and a collector, and the 3rd capacitor connected with the base of said transistor between said power supply terminals, It comprises a source of current connected to the collector of said transistor, and the connecting point of said 1st and 2nd capacitors is connected to the 2nd input edge of said multiplication means.

[0011]The amplitude limiting means to which FM signal is inputted and FM recovery circuit of this invention holds down the maximum voltage amplitude of said FM signal to a steady value, The phase shift means to which the output signal of said amplitude limiting means is inputted into, and only the specified quantity moves the phase of said FM signal, Have the 1st and 2nd input edges and the output signal of said amplitude limiting means is inputted into said 1st input edge, The output signal of said phase shift means is inputted into said 2nd input edge, have a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between the outgoing end of said amplitude limiting means, and the 1st power supply terminal, The 1st transistor by which a collector is connected to the connecting point of said 1st and 2nd capacitors, and an emitter is connected to said 1st power supply terminal, The 2nd transistor by which a collector is connected to the 2nd power supply terminal, and an emitter is connected to the base of said 1st transistor, The differential means

by which one input edge is connected to the connecting point of said 1st and 2nd capacitors, and the input edge of another side is connected to the base of said 2nd transistor, the source of the 1st current connected to the collector of said 1st transistor, and the source of the 2nd current connected to the emitter of said 2nd transistor, It comprises the 3rd capacitor connected with the base of said 2nd transistor between said 1st power supply terminals, and the emitter of said 2nd transistor is connected to the 2nd input edge of said multiplication means.

[0012]The amplitude limiting means to which FM signal is inputted and FM recovery circuit of this invention holds down the maximum voltage amplitude of said FM signal to a steady value, The phase shift means to which the output signal of said amplitude limiting means is inputted into, and only the specified quantity moves the phase of said FM signal, Have the 1st and 2nd input edges and the output signal of said amplitude limiting means is inputted into said 1st input edge, The output signal of said phase shift means is inputted into said 2nd input edge, have a multiplication means which outputs FM recovery signal, and, [said phase shift means] The 1st and 2nd capacitors by which series connection is carried out between the outgoing end of said amplitude limiting means, and the 1st power supply terminal, The transistor by which a base is connected to the connecting point of said 1st and 2nd capacitors, a collector is connected to the 2nd power supply terminal, and an emitter is connected to said 1st power supply terminal via the source of the 1st current, The differential means by which one input edge is connected to the source of reference voltage, the input edge of another side is connected to the emitter of said transistor via resistance, and an outgoing end is connected to the base of said transistor, It comprises the 3rd capacitor connected with the input edge of another side of said differential means between said 1st power supply terminals, and the emitter of said transistor is connected to the 2nd input edge of said multiplication means. Said amplitude limiting means, said phase shift means, and said multiplication means are accumulated into 1 chip.

[0013]

[Mode for carrying out the invention]Hereafter, FM recovery circuit of this invention is explained in detail, referring to Drawings. Drawing 1 shows the composition of FM recovery circuit in connection with an embodiment of the invention. This FM recovery circuit comprises the amplitude limiting means 111, the phase shift means 12, and the multiplication means 13. Have the amplitude limiting means 111 and the resistive elements R1-R7 and the npn type bipolar transistors Q7-Q12, [the phase shift means 112] It has the resistive element R, R8-R10, the npn type bipolar transistors Q0-Q2, the pnp type bipolar transistors Q4-Q6, the capacitor C, C1, and C2, The multiplication means 113 has the resistive element R11 - R23, the npn type bipolar transistor Q14 - Q17, Q21 - Q31, the pnp type bipolar transistor Q13, Q18 - Q20, the capacitor C3, C4, and C5.

[0014]FM signal is inputted into the base of the transistor Q7. The resistive element R1 is connected with the base of the transistor Q7 between the power supplies V, and the capacitor C and the power supply V are connected between the base of the transistor Q7, and the grounding point.

[0015]In the amplitude limiting means 111, the transistor Q7 and Q8 constitute a differential amplifier, and the transistor Q9 and Q10 constitute the differential amplifier. In the phase shift means 112, the transistor Q4 and Q5 constitute the current mirror circuit. The transistor Q4 and the size ratio of Q5 determine the size of the current sent through the transistor Q2. FM recovery signal is outputted by the transistor Q19 and the

collector of Q25 in the multiplication means 113.

[0016]FM recovery circuit of this invention has the feature in the composition of the phase shift means 112. That is, the output signal of the amplitude limiting means 111 is given to the base of the transistor Q1 and the transistor Q2, and the collector of Q4 via the capacitor C1, and it is given to the base of the input transistor Q3 of the multiplication means 113. The capacitor C2 is connected with the capacitor C1 between grounding points. The source I1 of current, the transistor Q4, Q5 and the resistance R8, and R9 constitute the circuit for supplying current to the collector of the transistor (voltage current conversion means) Q2. The source I1 of current can adjust a current value by resistance trimming etc., and can lose the frequency change by the variation at the time of manufacture.

[0017]It is connected to the emitter of the transistor Q1 via the resistance R, and the base of the transistor Q2 is connected to the grounding point via the capacitor C. The capacitor C and the resistance R constitute the low pass filter. The emitter of the transistor Q2 is connected to the grounding point. The collector of the transistor Q1 is connected to the power supply V, and the emitter is connected to the collector of the transistor Q0. The emitter of the transistor Q0 is connected to the grounding point via the resistance R10.

[0018]If base potential of the transistor Q1 is set to Vz when such a phase shift means 112 is used, the base potential V1 of the transistor Q2 can be given by the following (4) formulas in AC.

[0019]

[Mathematical formula 4]

$$V1 = \frac{\frac{1}{j\omega c}}{R + \frac{1}{j\omega c}} Vz = \frac{1}{1 + j\omega CR} Vz \qquad \cdots (4)$$

[0020]Here, if it assumes that it is so small that the transistor Q1 and the current gain beta of Q3 are large enough and base current can ignore from the collector current of the transistor Q2, the current iz can be denoted by (5) types.

[0021]

[Mathematical formula 5]

$$iz = gmV1 = \frac{gm}{1 + j\omega CR} Vz \qquad \cdots (5)$$

However, gm is the mutual conductance of the transistor Q2. Therefore, the impedance Z comes to be shown in the following (6) types.

[0022]

[Mathematical formula 6]

$$Z = \frac{Vz}{iz} = \frac{1 + j\omega CR}{gm} = \frac{1}{gm} + j\omega \frac{CR}{gm} \qquad \cdots (6)$$

[0023]That is, the resistance ingredient r serves as 1/gm, and the coil ingredient L serves as CR/gm. since [this] resistance and a coil can be formed in the inside of IC in equivalent obtaining, FM recovery circuit which reduced external parts can be provided.

[0024]According to the FM recovery circuit of this invention, a phase shift means is formed in a semiconductor (IC), and a coil (inductance) is constituted by the transistor Q1, Q2, the resistance R, and the capacitor C in equivalent. That is, the phase shift means 112 will be constituted by such an inductance and the capacitor (capacitance) C1, and the parallel resonant circuit of C2. Resonance angle frequency omega0 and the quality factor (coefficient showing the sharpness of resonance) Q come to be shown in the following (7) types and (8) types.

[0025]

[Mathematical formula 7]

$$\omega_0 = \frac{1}{\sqrt{(C1+C2)L}} \quad \cdots (7)$$

$$Q = \frac{1}{\omega_0 (C1+C2) r} \quad \cdots (8)$$

The inductance L, the resistance r, and the mutual conductance gm come to be shown in the following (9) - (11) types, respectively.

[0026]

[Mathematical formula 8]

$$L = \frac{CR}{gm} \quad \cdots (9) \qquad r = \frac{1}{gm} \quad \cdots (10)$$

$$gm = \frac{IC(Q2)}{VT} \quad \cdots (11)$$

[0027]As mentioned above, understanding is that the mutual conductance gm changes and the inductance L changes by changing collector current IC (Q2) of the transistor Q2. That is, according to this invention, since the resonance frequency f0 can be set up by adjusting collector current IC (Q2) of the transistor Q2 to a suitable value at the time of manufacture of IC (FM recovery circuit), FM recovery which absorbed manufacture variation is attained.

[0028]Drawing 2 shows the 1st modification of the phase shift means of drawing 1. Via the capacitor C1, it is connected to the collector of the transistor Q2, and the output signal of the amplitude limiting means is connected to the output terminal. The capacitor C2 is connected with the capacitor C1 between grounding points. The current generator I3 is connected with the power supply V among the collectors of the transistor Q2. The resistance R is connected between the base of the transistor Q2, and a collector, and the capacitor C is connected between the base and the grounding point. The emitter of the transistor Q2 is connected to the grounding point.

[0029]The number of elements is reduced compared with the phase shift means of drawing 1, and the phase shift means of this example can contribute to reduction-ization of a circuit scale and a chip. On the other hand, about the S/N ratio, the phase shift means of drawing 1 is superior to the phase shift means of this example.

[0030]Drawing 3 shows the 2nd modification of the phase shift means of drawing 1. The phase shift means

of this example is provided with the bipolar transistor by which differential connection was made, and has the feature at the point of not having a resistive element.

[0031]Via the capacitor C1, it is connected to the collector of the transistor Q2, and the output signal of the amplitude limiting means is connected to the base of the transistor Q32. The capacitor C2 is connected with the capacitor C1 between grounding points. The current generator I3 is connected with the power supply V among the collectors of the transistor Q2. The emitter of the transistor Q2 is connected to the grounding point.

[0032]The transistor Q32 and Q33 constitute the differential pair. The transistor Q32 and the emitter of Q33 are connected mutually, and the connecting point is connected to the grounding point via the source I1 of current. The collector of the transistor Q32 is connected to a power supply, and transistor Q33 base and the collector are connected to the power supply V via the source I2 of current. It is connected to the base of the transistor Q34, and the base of the transistor Q33 is connected to the grounding point via the capacitor C. The collector of the transistor Q34 is connected to the power supply V, it is connected to an output terminal and the emitter is connected to the base of the transistor Q2. The source I4 of current is connected with the emitter of the transistor Q34 between grounding points.

[0033]Also in the above composition, the same effect as FM recovery circuit of drawing 1 is acquired. Drawing 4 shows the 3rd modification of the phase shift means of drawing 1. The phase shift means of this example has the feature at the point of having the bipolar transistor by which differential connection was made.

[0034]Via the capacitor C1, it is connected to the collector of the transistor Q33, and the output signal of the amplitude limiting means is connected to the base of the transistor Q34. The capacitor C2 is connected with the capacitor C1 between grounding points. The current generator I2 is connected with the power supply V among the collectors of the transistor Q33. The collector of the transistor Q32 is connected to the power supply V.

[0035]The transistor Q32 and Q33 constitute the differential pair. The transistor Q32 and the emitter of Q33 are connected mutually, and the connecting point is connected to the grounding point via the source I1 of current. The source V3 of reference voltage is connected between the base of the transistor Q32, and the grounding point. It is connected to the emitter of the transistor Q34 via the resistance R, and the base of the transistor Q33 is connected to the grounding point via the capacitor C. The source I3 of current is connected with the emitter of the transistor Q34 between grounding points. An output terminal is connected to the emitter of the transistor Q34.

[0036]Also in the above composition, the same effect as FM recovery circuit of drawing 1 is acquired. FM recovery circuit of this invention is applicable to the receiving part of FM signals, such as television and radio, etc.

[0037]

[Effect of the Invention]As mentioned above, according to the FM recovery circuit of this invention, the following effects are generated as explained. Conventionally, a transistor, a capacitor, and resistance have realized in equivalent the coil (inductance) used as the external parts of IC in IC (semiconductor). That is, in the phase shift means in connection with this invention, the inductance L is denoted by C -R /gm, the

resistance r is denoted by 1/gm, and the mutual conductance gm is denoted by IC (Q2)/VT.

[0038]Therefore, according to this invention, reduction of the external parts of IC is attained. By changing collector current IC (Q2) of the transistor Q2, the mutual conductance gm changes and the inductance L changes. That is, according to this invention, since the resonance frequency f0 can be set up by adjusting collector current IC (Q2) of the transistor Q2 to a suitable value at the time of manufacture of IC (FM recovery circuit), FM recovery which absorbed manufacture variation is attained.

[Translation done.]